DATA EVALUATION RECORD

PC Code 128931/100094 **Dicamba, DGA, and BAPMA Salts**

Reference: Stevan Z Knezevic, O Adewale Osipitan, and Jon E Scott (2018). Sensitivity of Grape and Tomato to Micro-rates of Dicamba-based Herbicides. Journal of Horticulture, 5:229, doi: 10.4172/2376-0354.1000229

Test material: Clarity (Reg No. 7969-137); Engenia (Reg No. 7969-345); and XtendiMax (Reg No. 524-617)
Common name: Dicamba

Study classification: Supplemental

Primary Reviewer:	Michael Lowit, Ph.D. EPA Reviewer	2018.10.30 13:45:18 -04'00' Date
Secondary Reviewer:	Frank Farrugia, Ph.D. EPA Reviewer	2018.10.30 13:25:23 -04'00' Date
Secondary Reviewer:	EDWARD ODENKIRCHEN Ed Odenkirchen, Ph.D. EPA Reviewer	Digitally signed by EDWARD ODENKIRCHEN Date: 2018.10.30 16:21:47 -04'00' Date

Reviewer Conclusions:

This study evaluated the impact on tomato and grape plants after direct spraying of dicamba (three different formulations). Tomatoes and grapes were treated at five different rates of three dicamba-based products (Clarity, Engenia, and XtendiMax). Each species of plant was treated at two different stages of growth (based on tomato height and grape vine length). Separate experiments were conducted over two years. Plants were evaluated for severity of % injury (7, 14, 21, and 28 days after treatment (DAT)), tomato height/grape vine length (14 and 28 DAT), and plant biomass (14 and 28 DAT). Analysis of the data calculated the ED_{10}, ED_{20}, and ED_{50} of each measured variable.

The results related to plant growth were evaluated for the purposes of this review. Furthermore, this review focuses on the toxicity of DGA (Clarity and XtendiMax) and BAPMA (Engenia). Only length (i.e., tomato shoot height and grape vine length), was analyzed by the study author in terms of individual dicamba products, biomass estimates were combined across products in the study report. The reviewer estimated ED_5 and ED_{25} values to compare with results from registrant-submitted toxicity studies on dicamba. The authors did not provide their regression equations (described as a 4-parameter logistic regression) so the reviewer estimated the endpoints in Excel using linear, exponential, and power regression of the reported ED_x values for length and biomass. Linear regressions (intercept set to zero) were generally judged poor fits and were therefore excluded as reviewer calculated ED_5 values typically exceeded the reported ED_{10} values. The power and exponential regressions each fit the data well, however, in general power regression results were selected based on their r-squared estimates.

Reviewer estimated endpoints[1]

Tomato (shoot height)

<u>XtendiMax (DGA)[2]</u>
ED_5 = 0.086g ae/ha
ED_{25} = 1.067 g ae/ha

<u>Engenia (BAPMA)[2]</u>
ED_5 = 0.500 g ae/ha
ED_{25} = 2.064 g ae/ha

Tomato (biomass)[2]

<u>Dicamba (combined DGA and BAPMA study results)</u>
ED_5 = 0.079g ae/ha
ED_{25} = 1.211 g ae/ha

Grape (vine length)

<u>XtendiMax (DGA)[3]</u>
ED_5 = 0.477g ae/ha
ED_{25} = 0.876 g ae/ha

<u>Engenia (BAPMA)[2]</u>
ED_5 = 0.161 g ae/ha
ED_{25} = 1.879=g ae/ha

Grape (biomass)[2]

<u>Dicamba (combined DGA and BAPMA study results)</u>
ED_5 = 0.344 g ae/ha
ED_{25} = 3.156 g ae/ha

[1] The most toxic DGA product (Clarity or XtendiMax) is reported
[2] estimates by power regression
[3] estimates by exponential regression

Materials and Methods

Studies were conducted during summers of 2016 and 2017 at Haskell Ag Lab, Concord, NE (42.37°N, 96.68°W). “Frontenac” grape (J.W. Jung Seed Company, 335 S. High St Randolph, WI 53956) and “better boy” tomato (W. Atlee Burpee & Co 300 Park Ave Warminster, PA 18974) were the varieties used for the experiment. A 2 year old bare rootstocks (about 70 cm) and tomato seedlings (about 20 cm) were planted into 20 by 25 cm pots filled with moisture control potting mix (Miracle Gro, Marysville, OH).

The pot-grown grape and tomato were separately placed on the field in a randomized complete block design with 4 replicates. The treatment combinations were 3 dicamba-based products, 6 micro-rates 0.56, 1.12, 5.6, 11.2, 56 g ae/ha (0; 1/10; 1/50; 1/100; 1/500; 1/1000 of the label rate [560 g ae ha-1]) of each product, and 2 application timings in respect to crop height or vine length. Tomato heights at time of application were 25 and 45 cm, while vine lengths were 75 and 115 cm. To help reader visualize the amount of product on a per acre (0.4 ha) basis, the 1/10th of the label rate is equivalent of 3 tablespoons and 1/100th is a 1 teaspoon applied over a size of football field (1 acre; 0.4 ha). There were total of 20 plants for each treatment combination; 5 plants × 4 replicates. The 3 dicamba-based products were Clarity® (dicamba diglycolamine salt, 480 g l^{-1}), Engenia® (dicamba N,N- Bis-(3-aminopropyl)methylamine salt, 600 g l^{-1}) and XtendiMax® (dicamba diglycolamine salt, 350 g l^{-1}).

Herbicide applications were made using a CO2-pressurized backpack boom sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa through four 11004-VP flat spray nozzle tips (Turbo TeeJet Induction, Spraying systems Co., P.O. Box 7900, Wheaton, IL 60187). Wind speed at the time of application was below 4 km h^{-1} in both years. Air temperatures at time of herbicide application were 27 and 35°C in 2016 and 2017, respectively.

Visually rated injuries on the scale of 0 (no injury) to 100 (dead plant) were collected at 7, 14, 21 and 28 days after treatment (DAT). The injury symptoms included chlorosis, cupping of leaves, epinasty, stunting, and necrosis, depending on the crop and product rate. Maximum accumulated vine length of grape, plant height of tomato from plant base, and plant biomass were collected at 14 and 28 DAT.

Data for 2016 and 2017 were combined as there was no significant interaction between year and treatment. A four-parameter log-logistic regression model was used to analyze the relationship between dicamba micro-rates, and visual injury, vine length, plant height or biomass. The regression analyses helped estimate the dicamba micro-rates (ED values) causing a range of injury levels (e.g. 10, 20 and 50% threshold) or growth reduction. Regression analyses were conducted using R version 3.4.1 (R Core Team, 2017).

Summary of Relevant Information from Author's Results and Discussion

The authors report that the three products caused relatively similar % injury in grapes and tomatoes whereas the products differed in terms of impact on grape vine length by up to ca. 4X and plant height by up to ca. 3X depending on the EDx value (**Table 1** and **2**). Grapes showed less % injury when exposed at a later stage (i.e., longer vine length) but there was no statistical difference in terms of effect on biomass (**Table 3**). In contrast, tomato plants also showed less % injury when exposed at a later stage (i.e., greater plant height) but showed the opposite reaction in term of biomass (later stages were more sensitive).

Measurement	Dicamba	ED10 (SE)	1/X*	ED20 (SE) g ae ha^{-1}	1/X	ED50 (SE)	1/X
Injury	Clarity®	0.95 (0.28)	1/622	2.19 (0.45)	1/255	9.13 (1.32)	1/61
	Engenia®	1.07 (0.46)	1/523	2.29 (1.02)	1/245	8.24 (1.32)	1/67
	XtendiMax®	0.96 (0.31)	1/583	1.98 (0.47)	1/283	6.54 (0.81)	1/86
Vine length	Clarity®	0.93 (0.85)	1/603	2.02 (1.30)	1/277	7.59 (2.51)	1/73
	Engenia®	0.49 (0.21)	1/1142	1.21 (0.53)	1/463	5.64 (2.47)	1/99
	XtendiMax®	0.52 (0.29)	1/1076	0.82 (0.33)	1/682	1.83 (0.56)	1/306

1/X* was the diluted fraction of the label rate.

Table 1: Dose of Clarity®, Engenia® and XtendiMax® that resulted in 10%, 20% and 50% injury and vine length reduction of grape at 21 DAT.

Measurement	Dicamba	ED10 (SE)	1/X[a]	ED20 (SE) g ae ha⁻¹	1/X	ED50 (SE)	1/X
Injury	Clarity®	0.91 (0.32)	1/615	1.73 (0.44)	1/324	5.35 (0.94)	1/105
	Engenia®	0.82 (0.32)	1/683	1.45 (0.43)	1/386	3.96 (0.35)	1/141
	XtendiMax®	0.82 (0.29)	1/683	1.48 (0.39)	1/378	4.49 (0.52)	1/125
Plant height	Clarity®	0.42 (01.6)	1/1333	1.34 (0.54)	1/418	9.76 (3.01)	1/57
	Engenia®	1.10 (1.01)	1/509	1.92 (1.35)	1/292	5.01 (1.42)	1/112
	XtendiMax®	0.32 (0.19)	1/1750	0.93 (0.40)	1/602	5.77 (1.51)	1/97

1/X[a] was the diluted fraction of the label rate

Table 2: Dose of Clarity®, Engenia® and XtendiMax® that resulted in 10%, 20% and 50% injury and plant height reduction of Tomato at 28 DAT.

Crop	Measure	Stage	ED10 (SE)	ED20 (SE)⁻¹ g ae ha	ED50 (SE)
Grape	Injury	75 cm	1.93 (0.26)	2.03 (0.72)	9.02 (4.21)
		115 cm	7.91 (4.40)	21.41 (1.21)	60.18 (7.56)
	Biomass	75 cm	1.00 (0.21)	2.76 (1.01)	15.62 (5.73)
		115 cm	0.94 (0.41)	2.13 (0.92)	8.51 (3.64)
Tomato	Injury	25 cm	0.92 (0.15)	1.64 (0.17)	5.44 (2.62)
		45 cm	1.07 (0.06)	3.15 (1.22)	20.77 (9.51)
	Biomass	25 cm	1.39 (0.84)	8.82 (2.32)	14.44 (4.17)
		45 cm	0.33 (0.19)	1.04 (0.63)	7.53 (3.59)

Table 3: Dose of dicamba that resulted in 10%, 20% and 50% injury and biomass reduction of grape and tomato at 28 DAT for each time of application.

Deficiencies/Issues Related to Utility for EPA

- The number of plants used was low (20 plants for each treatment group and 5 plants per replicate) compared to 850 guideline expectations for a vegetative vigor study (30 plants minimum and 40 plants if the number of replicates is only 4, as in this study).
- It appears that the plants were located in a field during both the application and observation phases of the experiment. Environmental conditions during the experiment were not reported except for wind and temperature at the time of application.
- A randomized complete block design was used in the field; however, no details were provided about how cross-contamination was prevented among the plants in the different groups during the application phase (i.e., the controls, the five different treatment levels, the three different dicamba products, and the timing of applications to different growth stages). Furthermore, no details were provided on how cross-contamination was prevented after application given that dicamba is volatile. Although the tested products are designed to reduced volatility, they are not completely volatile-free according to the study authors.
- Experiments were conducted in 2016 and 2017 and the data from those experiments were combined for analysis. Presumably the full experimental design was repeated each year given the statement that "*Data for 2016 and 2017 were combined as there was no significant interaction between year and treatment*"; however, it is unclear.
- It is unclear how well the nominal application rates consistently represent relative exposure to each plant given that a backpack boom spray was used to apply the test material and no direct measurements of the application rates were provided for confirmation.

- It was not reported if biomass was measured for the entire plant or some portion (e.g., above ground). Furthermore, it was not stated if it was dry weight or wet weight.
- Raw data were not included and it is unclear how much the EDx values would vary depending on how the data were combined for analysis. EDx values for length and biomass may not be directly comparable because the former was analyzed by product and the later was analyzed by the stage of plant (i.e., height) at the time of measurement. Injury (phytotoxicity) was assessed by both product and plant stage. In some cases, there was little difference among the injury EDx values (e.g., among the products) while in others there was up to ca. an order of magnitude difference in the EDx values (e.g., between the two plant stages or among the by plant stages and by product values). The by plant stage and by product EDx values provide important information and varied; therefore, it would be useful to know how biomass and height EDx values were influenced by those design elements.
- Biomass EDx values were not expressed by product.
- The analysis did not calculate NOAEC values or EDx values.
- No indication as to how much water was used in the tank mix.
- The method description does not detail the approach taken to ensure consistency in the identification of various injury effect levels.